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(56) Documents Cited

GB 2138190 A **EP 0667240 A2** **FR 002692839 A**
US 5978006 A **US 5432533 A** **US 4168421 A**
US 4113391 A

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(54) Abstract Title

Method of controlling a thermal print head

(57) The method includes controlling a thermal print head (16, Fig. 2) which comprises selectively heated print elements (120, Fig. 4) to ensure uniform print density without any form of voltage regulation. To compensate for changes in a condition of a battery 200 and print head resistance, the print head is activated by an initial pulse of predetermined time, during which the voltage across the print head is measured 202 and the time over which the print head is activated is extended in response to the measured voltage. In addition, strobe time is also adjusted for print elements activated in a previous print cycle.

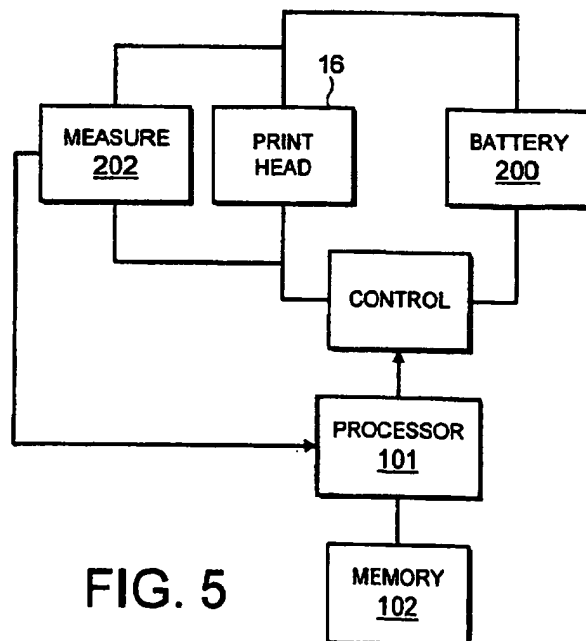


FIG. 5

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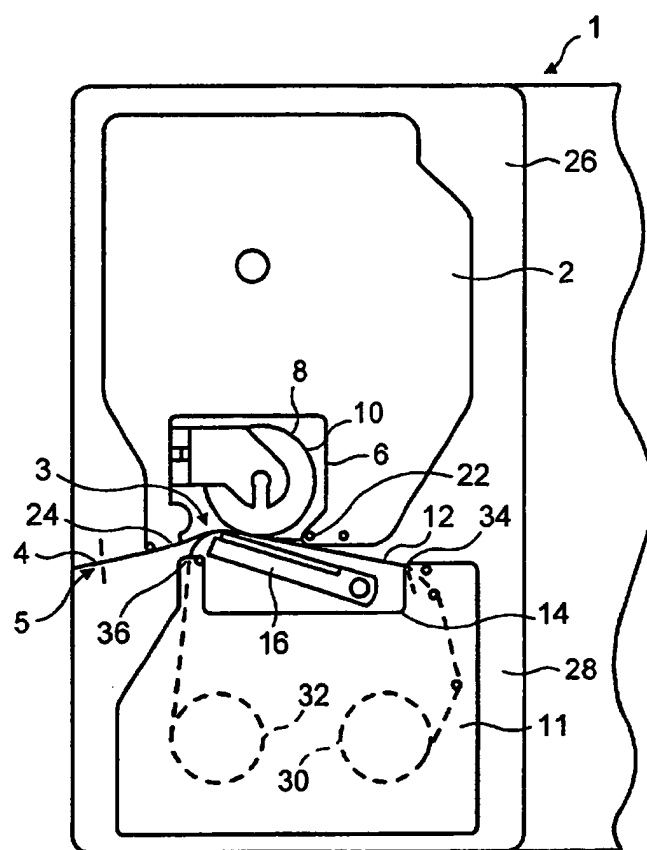
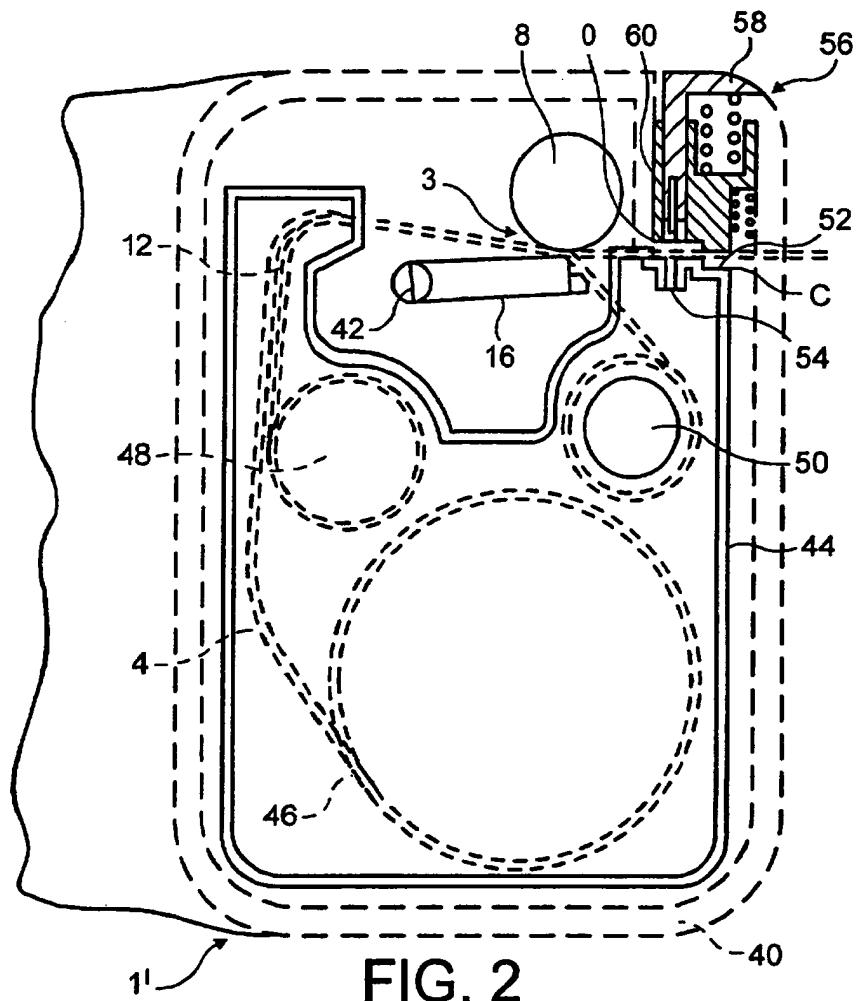


FIG. 1



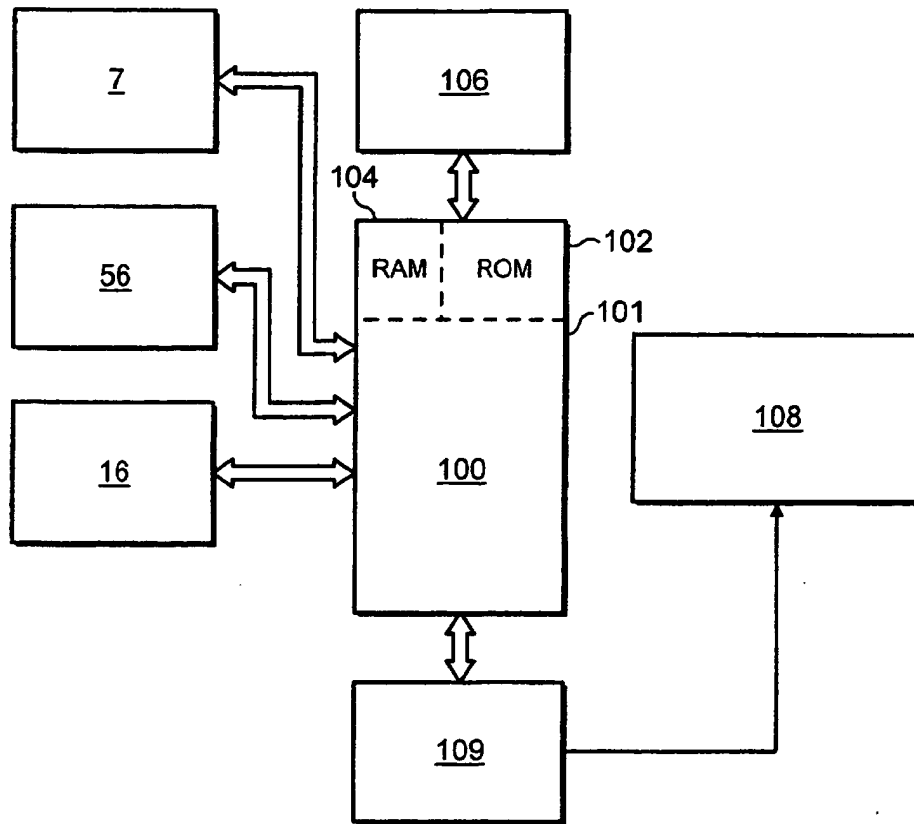


FIG. 3

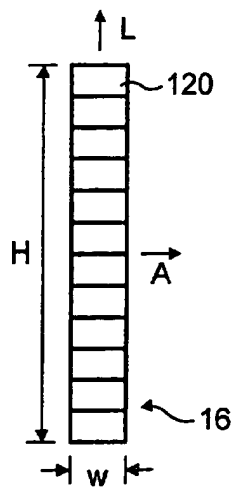


FIG. 4

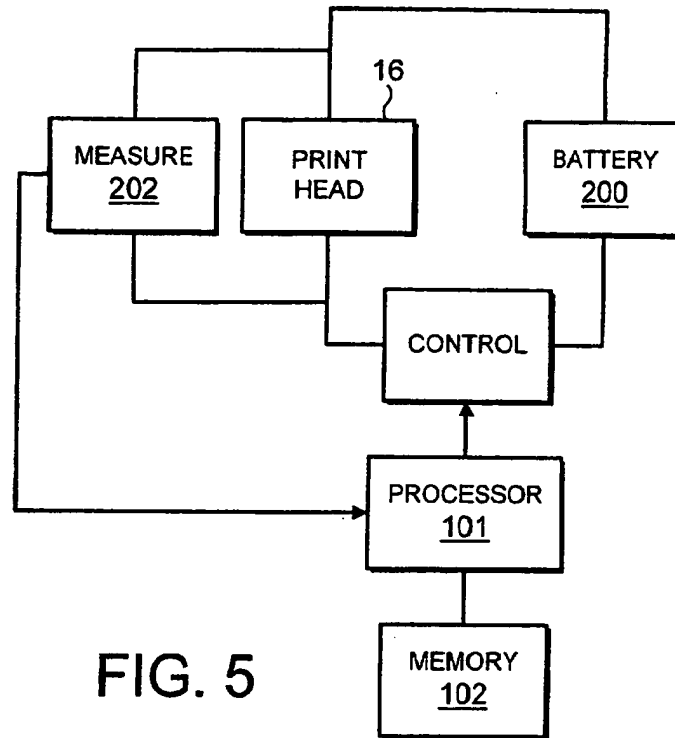


FIG. 5



FIG. 6a

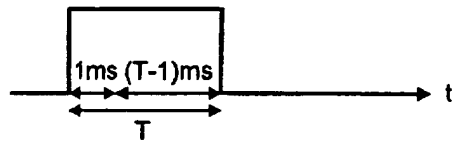


FIG. 6b

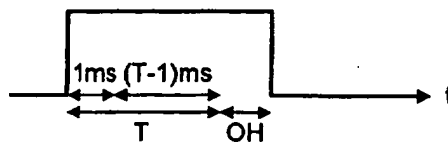


FIG. 6c

5

A METHOD OF CONTROLLING A PRINT HEAD

The present invention relates to a method of controlling a print head and, in particular, but not exclusively to a method of controlling a print head of a tape printer. The present invention also relates to a print head arrangement.

Known tape printing apparatus of the type with which the present invention is concerned are disclosed in EP-A-322918 and EP-A-322919 (Brother Kogyo Kabushiki Kaisha) and EP-A-267890 (Varitronics). The printers each include a printing device having a cassette receiving bay for receiving a cassette or tape holding case. In EP-A-267890, the tape holding case houses an ink ribbon in a substrate tape, the latter comprising an upper image receiving layer secured to a backing layer by an adhesive. In EP-A-322918 and EP-A-322919, the tape holding case houses an ink ribbon, a transparent image receiving tape and a double sided adhesive tape which is secured at one of its adhesive coated sides to the image tape after printing and which has a backing layer peelable from its other adhesive coated side. With both these apparatus, the image transfer medium (ink ribbon) and an image receiving tape (substrate) are in the same cassette.

It has also been proposed by the present applicants in, for example, EP-A-578372 to house the ink ribbon and the substrate tape in separate cassettes.

In all of these cases, the image receiving tape passes in overlap with the ink ribbon to a print zone consisting of a fixed print head and a platen against which the print head can be pressed to cause an image to transfer from the ink ribbon to the image receiving tape. There are many ways of doing this, including dry lettering or dry film impression, but the most usual way currently is by thermal printing

5 where the print head is heated and the heat causes ink from the ink ribbon to be transferred to the image receiving tape.

10 The print head for such printing apparatus generally comprises a plurality of printing elements which are selectively activated, that is heated. The activated printing elements of the print head heat up which causes the ink from the parts of the ink ribbon in contact with the heated printing elements to be transferred to the image receiving tape. Alternatively, the heated printing elements may directly contact a thermally sensitive image receiving tape which causes an image to be formed thereon. These known print heads generally comprise a column of printing elements which have a height which corresponds generally to the width of the image receiving tape which is used.

Tape printing apparatus are generally designed so as to be small and relatively portable. Accordingly, some tape printing apparatus are battery powered. Accordingly, it is desirable to maximise the efficiency of the tape printer. In conventional tape printing apparatus, the tape is moved past the print head and the print head is activated in cycles to provide the desired image on the image receiving tape. A typical print cycle will last for 10 msec. The printing elements, which are to be activated in that cycle are activated for 2 msec of that cycle. There will then be a rest period of 8 msec when no printing element of the print head is activated. This is used to allow the power supply to recover and also to allow the print head to cool down. In order to maintain the print quality for the required two msec of the cycle, a switching (high voltage) regulator is required in order to maintain the required current voltage levels. This is relatively expensive.

40 It is an aim of embodiments of the present invention to address this disadvantage of the known tape printers.

5

According to a first aspect of the present invention there is provided a method of controlling a print head comprising the steps of activating one or more printing elements of the print head for a predetermined time; measuring the voltage
10 across the print head during said predetermined time; and extending the predetermined time for which the one or more printing elements are activated in response to the measured voltage.

15 It should be appreciated that embodiments of the present invention do not require any form of voltage regulation. In particular, the use of linear or controlled voltage drop type regulators and switching types of power supply regulators can be avoided.

20

The method may also comprise a step of determining the time for which the printing elements are to be activated.

A look up table may be provided with the measured voltage
25 being used as an address to the look up table with the look up table providing information as to how long the predetermined time may be extended. Alternatively, an algorithm may be provided with the measured voltage being input into the algorithm to provide information as to how
30 long the predetermined time is to be extended. It should be appreciated that in some embodiments of the present invention, an algorithm and a look up table may be used.

The algorithm may use the formula $T=K/V^2$ where T is the total
35 length of time for which one or more of the printing elements is activated and K is a constant. The constant K may take into account the characteristics of the print head.

In preferred embodiments of the present invention, the
40 voltage may be measured at approximately halfway through the predetermined time.

5

The method may comprise the steps of determining for each of the one or more printing elements which are activated if the respective printing element has been activated in a previous cycle. Preferably, those printing elements which have been
10 previously activated are activated for a shorter time than those printing elements which have not been activated in a previous cycle. The extended predetermined time may be further extended for each printing element which is activated and which has not been previously activated in a
15 previous cycle.

According to a second aspect of the present invention there is provided a print head system comprising a print head having a plurality of printing elements which are
20 selectively activatable for a predetermined time; voltage measuring means for measuring the voltage across the print head during the predetermined time; and means for extending the time for which the one or more printing elements are activated in response to the measured voltage.

25

Preferably, means are provided for determining the amount of time for which the printing elements are to be activated. A look up table may be provided, with the measured voltage being used as an address for the look up table, the look up
30 table providing information as to how long the predetermined time is to be extended. Alternatively or additionally, an algorithm may be provided, with the measured voltage being input to the algorithm to provide information as to how long the predetermined time is to be extended.

35

According to a further aspect of the present invention, there is provided a tape printer incorporating a print head system as described earlier.

40 For a better understanding of the present invention and as to how the same may be carried into effect, reference will

5 now be made by way of example to the accompanying drawings in which:

- Figure 1 is a plan view of a first tape printing device embodying the present invention using a two cassette system;
- 10 Figure 2 is a plan view of a second tape printing device embodying the present invention, using a one cassette system;
- Figure 3 is a diagrammatic sketch showing the control circuitry for the printing device of Figure 1 or of Figure
- 15 2;
- Figure 4 shows a schematic view of the print head of Figure 1 or Figure 2;
- Figure 5 shows a schematic view of the control circuitry for controlling the print head; and
- 20 Figure 6 shows the relationship between current and time for the print head.

Figure 1 shows in plan view the first tape printing device embodying the present invention which has two cassettes

25 arranged therein. Typically, this tape printing device 1 is a hand held or small desk top device which is powered by batteries at least part of the time. The upper cassette 2 is located in a first cassette receiving portion 26 and contains a supply of image receiving tape 4 which passes

30 through a print zone 3 of the tape printing device 1 to an outlet 5 of the tape printing device 1. The image receiving tape 4 comprises an upper layer for receiving a printed image on one of its surfaces and has its other surface coated with an adhesive layer to which is secured a

35 releasable backing layer. The upper cassette 2 has a recess for accommodating a platen 8 of the tape printing device 1, and guide portions 22 and 24 for guiding the tape through the print zone 3. The platen 8 is mounted for rotation within a cage moulding 10. Alternatively, the platen could

40 be mounted for rotation on a pin.

5 The lower cassette 11 is located in a second cassette receiving portion 28 and contains a thermal transfer ribbon 12 which extends from a supply spool 30 to a take up spool 32 within the cassette 11. The thermal transfer ribbon 12 extends through the print zone 3 in overlap with the image receiving tape 4. The cassette 11 has a recess 14 for
10 receiving a print head 16 of the tape printing device 1 and guide portions 34 and 36 for guiding the thermal transfer ribbon 12 through the print zone 3. The print head 16 is movable between an operative position shown in Figure 1, in
15 which it is in contact with the platen 8 and holds the thermal transfer ribbon 12 and the image receiving tape 4 in overlap between the print head 16 and the platen 8 and in an inoperative position in which it is moved away from the platen 8 to release the thermal transfer ribbon 12 and image
20 receiving tape 4. In the operative position, the platen 8 is rotated to cause the image receiving tape 12 to be driven past the print head 16 and the print head 16 is controlled to print an image on the image receiving tape 4 by thermal transfer of ink from the ribbon 12. The thermal print head
25 16 is shown in Figure 4 and comprises a column of printing elements 120a. The print head 16 has a height H which is large enough to print on the widest width of tape. The print head has a width w which is equal to the width of one printing element. Each of the printing elements is
30 activatable separately and is activated in accordance with the desired image to be printed.

The tape printing device 1 has a lid (which is not shown) but which is hinged along the rear of the cassette receiving
35 portions 26 and 28 and which covers both cassettes when in place.

A dc motor 7 (see Figure 3) continuously drives the platen 8. The platen is arranged to drive the image receiving tape
40 4 through the print zone 3 by the actuation of its own rotation.

5

The image is printed by the print head 16 on the image receiving tape on a column by column basis with the columns being adjacent one another in the direction of movement of the tape 4.

10

Figure 2 illustrates in plan view a cassette bay of a second printing device 1' embodying the present invention which uses a one cassette system. Like reference numerals are used for those parts which are also shown in Figure 1. The cassette bay is shown by the dotted line 40. The cassette bay 40 includes a thermal print head 16 and a platen 8 which cooperate to define a print zone 3. The thermal print head 16 is the same as that discussed in relation to Figure 1 and shown in Figure 4.

20

The print head 16 is pivotable about a pivot point so that it can be brought into contact with the platen 8 for printing and moved away from the platen 8 to enable the cassette to be removed and replaced as in the first embodiment. A cassette inserted into the cassette bay 40 is denoted generally by reference numeral 44. The cassette 44 holds a supply spool 46 of image receiving tape 4. The image receiving tape 4 is guided by a guide mechanism (which is not shown) through the cassette 44, out of the cassette 44 through an outlet O past the print zone 3 to a cutting location C. The same cassette 44 also has an ink ribbon supply spool 48 and an ink ribbon take up spool 50. The ink ribbon 12 is guided from the ink ribbon supply spool 48 through the print zone 3 and taken up on the ink ribbon take up spool 50. As with the first embodiment, the image receiving tape 4 passes in overlap with the ink ribbon 12 through the print zone 3 with its image receiving layer in contact with the ink ribbon 12. The platen of this second embodiment is also driven by a motor 7. The motor rotates to drive continuously the image receiving tape through the print zone 3 during printing. In either of the embodiments,

40

5 it is possible that the tape be driven in a step wise manner by a stepper motor.

An image is printed on the tape fed out from the print zone to the cutting location C which is provided at a location in a portion of the wall of the cassette 44 which is close to the print zone 3. The portion of the wall on the cassette 44 where the cutting location C is defined is denoted by reference 52. A slot 54 is defined in the wall portion 52 and the image receiving tape 4 is fed past the print zone 3 to the cutting location C where it is supported by facing wall portions on either side of the slot 54.

The second tape printing device 1' includes a cutting mechanism 56 including a cutter support member 58 which carries a blade 60. The blade 60 cuts the image receiving tape 4 and then enters the slot 54. It should be appreciated that the first embodiment will usually also include a cutting mechanism.

25 Basic circuitry for controlling the tape printing device 1 of Figure 1 or the tape printing device 1' of Figure 2 is shown in Figure 3. There is a microprocessor chip 100 having a read only memory (ROM) 102, a microprocessor 101 and random access memory capacity indicated diagrammatically by RAM 104. The microprocessor chip 100 is connected to receive label data input to it from a data input device such as a keyboard 106. The microprocessor chip 100 outputs data to drive a display 108 via a display driver chip 109 to display a label to be printed (or a part thereof) and/or a message for the user. The display driver alternatively may form part of the microprocessor chip. Additionally, the microprocessor chip 100 also outputs data to drive the print head 16 so that the label data is printed onto the image receiving tape to form a label. Finally, the microprocessor chip 100 also controls the motor 7 for driving the platen. The microprocessor chip 100 may also control the cutting

- 5 mechanism 56 of Figure 2 or a cutting mechanism of Figure 1 to allow a length of tape to be cut off. In alternative embodiments at least part of the cutting mechanism may be manually operated.
- 10 The type of print head 16 with which embodiments of the present invention are concerned is shown in Figure 4 and generally comprises a plurality of printing elements 120 which are selectively heated to allow thermal printing to take place. The thermal printing can be directly onto
- 15 thermally sensitive image receiving tape 4 or can be by means of an ink ribbon 12 such as shown in the embodiments of Figures 1 and 2. As discussed in relation to these embodiments, the ink ribbon 12 is arranged between the print head 16 and the image receiving tape 4. The application of
- 20 heat to the ink ribbon 12 by selected printing elements 120 of the print head 16 causes an image to be transferred to the image receiving tape. Each printing element 120 is generally square to print a square pixel on the image receiving tape. However, the printing elements may be
- 25 rectangular or the like.

Each printing element 120 is a resistive element which, when current has passed therethrough is heated up. The printing elements 120 are selectively heated so as to allow an image

30 to be printed on the image receiving tape 4 as it passes the print head 16. The image printed on the image receiving tape 4 is defined by a plurality of contiguous or adjacent columns of pixels. Thus the image printed on the image receiving tape 4 depends on which printing elements 120 are

35 activated or heated and when. The image receiving tape 4 moves generally in the direction of arrow A, that is in the length wise direction of the image receiving tape 4 and perpendicular to the longitudinal axis L of the print head 16.

5 The schematic representation of the print head shown in Figure 4 has twelve printing elements. In practice, the print head will have many more printing elements, for example 128. The print head 16 will generally have a height H slightly less than the width of the image receiving tape 4
10 to be used with the tape printing device 2. Where more than one width of tape is to be used with the tape printing device 2, the print head 16 will generally have a height H corresponding to the width of the largest image receiving tape 4 to be used with the tape printing device 12.
15 Generally, the width W of the print head is equal to the width w of one printing element 120 to thereby form a column shaped print head 16.

Reference will now be made to Figure 5. The print head 16 is
20 connected to a battery 200. The full battery voltage is connected to the print head 16 when a current is applied to the print head to heat up and activate respective printing elements. The voltage provided by the battery will vary over time as the battery becomes run down. Accordingly, the
25 circuitry shown in Figure 5 is arranged to dynamically adjust the strobe timings depending on the state of the batteries. The strobe timing is the length of time to which a current is applied to a given printing element.

30 When a print head strobe is enabled, this results in a current flowing through the selected printing elements. This current results in a voltage drop across the batteries. The voltage drop increases as the cells discharge and their internal resistance increases. At the end of a given length
35 of time, the voltage provided by the batteries when a current flows through the selected printing elements is measured. This voltage measurement effectively allows the voltage dropped across the print head to be measured.

40 The voltage is measured by a measurement arrangement 202 which includes an analogue to digital converter. This

- 5 analogue to digital converter converts the measured voltage into a digital signal. It should be appreciated that in some embodiments of the present invention, the measurement circuitry 202 may form part of the microprocessor.
- 10 The digital value of the measured voltage is supplied to the microprocessor 101. The microprocessor 101 obtains a formula from the read only memory 102 and uses the formula and the measured voltage value in order to determine for how long the initial pulse should be extended in order to compensate
- 15 for the drop in voltage.

If the voltage falls below a minimum level, then the printing operation will be aborted and the tape printer will return to the edit mode. The display 108 will display a

20 message indicating that the battery is low. This can be displayed by suitable wording or by the use of a given annunciator.

The memory 102 stores the strobe energy as a constant ER.

25 This constant is the product of the nominal energy required E and the nominal print head resistance R. During the production of the tape printer, links on the printed circuit board may be set to compensate for variations in the print head characteristics, such as the resistance of the elements

30 which effects the strobe timings. Reference is made to European Patent Application No 96305079.4.

A microcontroller has a number of open circuit links, each of which represents a different strobe time. The link which

35 is selected represents the strobe time option which best compensates for the variation in print head resistance of the actual print head. The remaining links are left open. Alternatively, the keyboard matrix has an additional line. Intersections with the different lines of the keyboard

40 matrix represent different strobe times. One intersection will be closed and the remaining are open. This selected

5 intersection represents the require strobe time. The selected strobe times ensures that the print head will perform in a known way when a known amount of energy is applied.

10 The user is also able to set contrast settings, that is how black the character appears. This will also effect the strobe timing.

Before a new label is printed, the print head links on the additional line or microcontroller are checked. This effectively determines how the print head behaviour is to be compensated in order to achieve a certain performance. The contrast settings are also used to determine correction multipliers. ER' is calculated. ER' represents ER after
20 being compensated for the particular characteristics of the print head and the contrast setting selected by the user.

During printing, each time a pixel is to be printed, the appropriate dots are energised for, for example, one msec
25 (see Figure 6a). This represents the nominal precalculated pulse width. The voltage is read by the microprocessor halfway through the $1mg$ period and the correct strobe period is calculated using the formula $T=ER'/v^2$ where T = the total strobe time including the initial precalculated pulse width
30 and V is the measured battery voltage across the print head. The dots which are energised are then kept energised for a further $T-1$ m sec to bring the total strobe length to T m secs (see Figure 6b).

35 One m sec will, on average, be approximately midway through time T so that an average voltage reading is achieved. In other embodiments of the present invention, the initial pulse is preferably midway through time T but depending on the construction of the apparatus including the available
40 voltage, the initial pulse will be more or less than one m sec.

5

The print quality can be effected by the thermal inertia of the print head resistor elements. In other words, if the print head element is cold because it has not been activated recently, it will require more energy than a recently heated element to produce the desired dot. Similarly, a "hot" element which has been activated, for example in a previous cycle requires less energy to produce a correctly printed dot. In order to deal with this, the microprocessor will maintain a history of the previously printed dot pattern. In other words, the printing elements which have been activated in the previous one or more cycles is stored. Preferably, only the printing elements which have been activated in the previous cycle are stored. However, in alternative embodiments, the activation of printing elements in two or more previous cycles can be stored. This stored information is used to adjust the strobe timings so that dots which were heated in a previous cycle are kept energised for a shorter time than those which have not.

25 The microprocessor performs an algorithm which takes information defining which printing elements are activated in the current print column and XOR (exclusive OR function) it with information defining which printing elements were activated in the previous printing cycle. The resulting pattern is added with the information defining which printing elements of the current print column are to be activated. This can be seen from the following example. In this example, the print head comprises seven elements. The current column is represented as follows: 0101110. 0 indicates that the printing element is not to be activated in the current printing cycle and 1 indicates that the printing element is to be activated. Each of the values represents the state of a respective one of the printing elements. In the previous printing cycle, the activation of the print head can be represented as follows: 0110101. When the current column is XORed with the previous column, the

5 result is 0011011. This XOR result is ANDed with the current column to give the following result: 0001010. As can be seen, the fourth and sixth bit of the print head column have a one value which indicates that the fourth and sixth printing elements should be heated longer than the second and fifth printing elements. The fourth and sixth printing elements are heated for a time greater than T. The remaining printing elements are heated for a time T. This is because the fourth and sixth printing elements were not on in the previous cycle.

15 The printing elements which require a boost are energised for a fraction of time T. This fraction can be, for example 25% or any other suitable value. Typically, a predefined percentage of T is used as the additional reenergisation time. Alternatively, the additional time can be calculated as required. The additional energisation required because the printing element was not activated in a previous cycle may be a predefined time.

25 In some embodiments of the present invention, the dots at the extreme edge of the print head will always be activated for an additional length of time if they are to be activated in a given cycle, regardless of whether or not they have or have not been activated in a previous cycle. This can be achieved in practice by ORing the result of the ANDing operation with a pattern with the top and bottom bits set to one and the intervening bits set to zero, i.e. the pattern 1000001.

35 Reference is made to Figure 6c which shows the additional time DH for which a printing element which has not been activated in a previous cycle but which is activated in the current cycle is heated.

40 The trigger for the next column will be an encoder wheel attached to the driving mechanism for the tape. There may

5 then be a gap in time before the print head is energised again. In some embodiments of the present invention, the print head may be activated more than once in a given printing cycle.

10 In one alternative embodiment of the present invention, the algorithm may be replaced by a look up table. The digital value of the measured voltage acts as an address to the look up table. The look up table stores values of T for different voltages. The looked up value of T can then be processed as
15 described hereinbefore.

One additional modification may be made to the arrangement described. Preferably, the full battery voltage is applied to the print head. However, it may be necessary to provide a
20 switch which removes the voltage from the print head when the printer is inactive. Typically, this switch will be a transistor which has a finite voltage drop which, if not taken into account, will reduce the total energy supplied per dot and thus effect print quality. Usually, this
25 transistor will be incorporated within the print head driver integrated circuit so that access cannot be gained to measure the actual voltage applied to the print elements. To compensate for this, the assumed voltage drop is subtracted from the measured print head voltage. This leads to the
30 following modified equation:

$$t = \frac{E.R}{(V_{ph} - V_{tvd})^2}$$

where V_{ph} is the measured voltage, V_{tvd} is the switched transistor voltage drop - a constant. In other words $V_{ph} -$
35 V_{tvd} is the assumed actual voltage applied to the print elements.

5 CLAIMS:

1. A method of controlling a print head comprising the steps of:
 - 10 activating one or more printing elements of the print head for a predetermined time;
 - measuring the voltage across the print head during said predetermined time; and
 - extending the predetermined time for which the one or
 - 15 more printing elements are activated in response to the measured voltage.
2. A method as claimed in claim 1, further comprising the step of determining the time for which said printing
- 20 elements are to be activated.
3. A method as claimed in claim 2, wherein a look up table is provided, said measured voltage being used as an address to the look up table, said look up table providing
- 25 information as to how long the predetermined time is to be extended.
4. A method as claimed in claim 2, wherein an algorithm is provided, said measured voltage being input into said
- 30 algorithm to provide information as to how long the predetermined time is to be extended.
5. A method as claimed in claim 4, wherein said algorithm uses the formula $T=K/V^2$ where T is the total length of time
- 35 for which one or more of the printing elements is activated is a constant and V is the voltage.
6. A method as claimed in claim 5, wherein said constant K takes into account the characteristics of the print head.

- 5 7. A method as claimed in claim 4 or 5, wherein a compensation voltage is subtracted from the measured voltage to provide V, the compensation voltage taking into account the voltage drop across a switch of said print head.
- 10 8. A method as claimed in any preceding claim, wherein said voltage is measured at approximately halfway through said predetermined time.
- 15 9. A method of controlling a print head as claimed in any preceding claim, comprising the steps of determining for each of the one or more printing elements which are activated if the respective printing element has been activated in a previous cycle, wherein those printing elements which have been previously activated are activated
20 for a shorter time than those printing elements which have not been activated in a previous cycle.
10. A method as claimed in claim 9, wherein the extended predetermined time is further extended for each printing
25 element which is activated and which has not previously been activated in a previous cycle.
11. A print head system comprising: a print head having a plurality of printing elements which are selectively
30 activatable for a predetermined time; voltage measuring means for measuring the voltage across the print head during the predetermined time; and means for extending the time for which the one or more printing elements are activated in response to the measured voltage.
- 35 12. A system as claimed in claim 11, wherein means are provided for determining the amount of time for which the printing elements are to be activated.
- 40 13. A system as claimed in claim 12, wherein a look up table is provided, the measured voltage being used as an

5 address for the look up table, said look up table providing
information as to how long the predetermined time is to be
extended.

10 14. A system as claimed in claim 12, wherein an algorithm
is provided, said measured voltage being input to said
algorithm to provide information as to how long the
predetermined time is to be extended.

15 15. A system as claimed in claim 14, wherein the algorithm
uses the equation $T=K/V^2$ where T is the time for which the
one or more printing elements are to be activated, V is the
measured voltage and K is a constant.

20 16. A system as claimed in any of claims 11 to 15, wherein
the measuring means are arranged to measure the voltage
approximately halfway through said predetermined time.

25 17. A tape printer comprising a system as claimed in any of
claims 11 to 16.

18. A tape printer as claimed in claim 17, wherein the tape
printer comprises a battery, the battery voltage being
applied across the print head.

30



Application No: GB 9927596.8
Claims searched: 1-18

Examiner: Gary Williams
Date of search: 12 June 2000

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B6F: FL8

Int Cl (Ed.7): B41J: 2/35,2/355,2/36

Other: Online:EPODOC,PAJ,WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2138190 A (MONARCH) See Fig.2, page 4 line 18 - page 5 line 37, page 6 lines 53-65	1-5,11-14,15,17,18
X	EP 0667240 A2 (MONARCH) See Fig.1, col.4 lines 32-53, col.5 line 28 - col.7 line 28	1,2,11,12,17
X	FR 2692839 A (SAGEM) 31.12.93 (See Figs.1&2, page 10 line 23 - page 12 line 15, and also WPI Abstract Accession No. 94/037011/05).	1,2,11,12
X	US 5978006 (GEMPLUS) See Fig.5, col.4 line 62 - col.7 line 23	1-4,11-14
X	US 5432533 (CANON) See Figs.2&3, col.4 lines 41-55, col.5 lines 34-48	1,2,11,12
X	US 4168421 (SHINSU SEIKI) See Figs.4-6, col.3 line 18 - col.5 line 2 & lines 56-65	1,2,11,12
X	US 4113391 (SEIKOSHA) See Figs.4,6,7, col.4 line 60 - col.5 line 13, col.6 line 29 - col.7 line 64, col.9 lines 23-38	1,2,11,12

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